1.1 OBJECTIVES

After reading this unit you will be familiar with the following :

- The types of wheat, structure of wheat grain, milling of wheat, wheat products and functionality of wheat flour components.
- Milling of rice, methods of parboiling rice, traditional and processed rice products.
- Maize milling and maize products
- Smaller millets like ragi, jowar, bajra, oats and barley and so on.

1.2 INTRODUCTION

Cereals and millets are major food grains used as staple. They form a major portion of diet in many populations supplying almost 60-70% of dietary energy. Growing of cereals as a food crop signifies the beginning of cultivated agriculture to mankind. This most probably could have been due to excellent storage stability of these dry grains which provided food security to otherwise nomadic society of hunterers and gatherers. Cereal grains and millets belong to the grass family. The word cereal is derived from 'ceres', the Roman Goddess of grain. The principal cereal crops are rice, wheat, maize, jowar, ragi and bajra. The relatively bland taste, pleasant flavor, good yield, low cost of cereals and ease of incorporating them into varied products has made them a popular food item. Millets, though grown and used in lesser quantities compared to cereals, are equally nutritious and can replace cereals in diets.

Structurally all cereal grains consist of three different portions, namely bran, which is the outermost layer of the grain, endosperm, which is the inner starchy portion and the germ or the embryo. The relative proportions of these differ depending upon the type of grain. These structural features are common to all grains and form the basis of subsequent milling and other processing operations. For most food uses, processors remove the hulls which are largely indigestible by man, the bran layer, which may be dark in colour, and coarse in texture due to high fiber content and the germ which is high in oil, is enzymatically active and can cause rancidity in the milled flour. Many a times the isolated bran fractions are added back to preserve the nutritive value. All cereals share a general similarity in composition and nutritional properties, composed principally of starch followed by protein and lesser amount of lipids and non starch polysaccharides.

Most of the cereal grains need to undergo dehusking or milling or both before they can be

used in any product. This is called as primary processing. Since each cereal has a different size, shape, hardness, and end uses, they require different processing techniques. We will discuss about the important aspects of processing of cereal grains and millets.

1.3. WHEAT

Worldwide, wheat is the most abundant food crop and essentially equal to rice in the amounts harvested. It is believed to be oldest food crop to have been milled at least 75,000 years ago. It is used as a base ingredient for preparing many types of products. Have you ever wondered why we can not make chapatis with rice flour or ragi flour? Can you roll out the rice or ragi dough like wheat dough? Wheat is unlike all other cereal grains and unique in several respects –

- It can form cohesive dough with viscoelastic properties. Other cereals do not form viscoelastic dough.
- It can retain gas; hence can produce light, leavened products.
- It sets into a semi rigid structure on application of heat, thereby providing shape and texture to the product.

Because of these unique properties wheat can be used in making many types of products - baked, fried, roasted, leavened, unleavened, fermented etc. And it is not possible to produce these products using other cereal flours.

1.3.1. Types of wheat

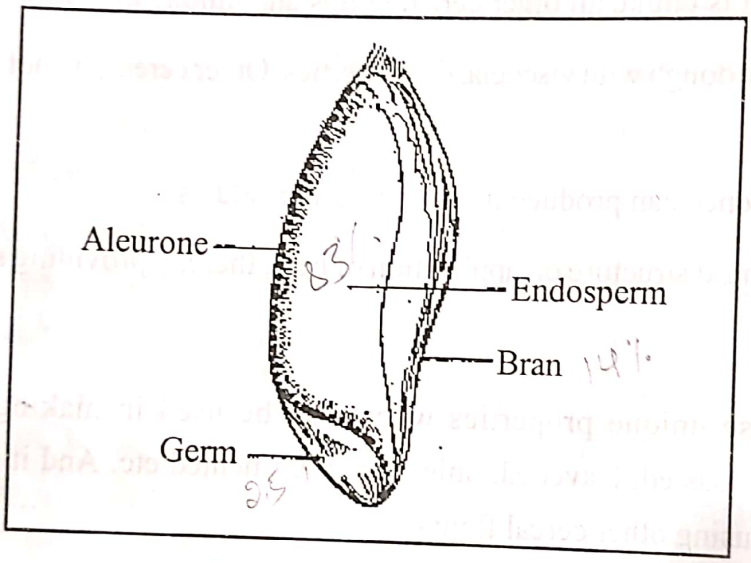
Worldwide many varieties of wheat are grown. They differ in their composition and suitability for incorporation into products. Most of the wheat grown for bread and a wide variety of other baked products is common wheat (*Triticum vulgare* or *Triticum aestivum*) while a closely related species *Triticum durum* is used for pasta products and breakfast cereals. Commercially three genetic types of wheat are grown as given below –

Variety	Type	Uses
1. Common wheat	Hard	Bread
	Soft	Cookies, crackers and cakes
2. Durum wheat	Hard	Pasta products
3. Club wheat	Very soft	Tender cookies

In comparison with soft wheat, hard wheat is higher in protein, yields a stronger flour, and is used for bread making because it gives a strong elastic dough. In contrast, soft wheat is lower in protein, yields weaker flour, forms weak dough or batters and is suitable for cakes, biscuits and cookies.

1.3.2. Structure of wheat grain

Wheat grain consists of bran (14%), germ portion (2.5%) and endosperm (83%). Endosperm is covered with aleurone layer, which is separated with bran. Endosperm contains smaller and larger starch granules embedded in a protein matrix. Germ portion is rich in lipids and vitamin E.



Structure of wheat grain

1.3.3. Milling of wheat

Traditional milling of wheat is done using plate mills, which gives whole wheat flour. Modern milling consists of separation of bran and germ from the endosperm and reduction of endosperm to fine flour. Milling conditions are adjusted to the type of wheat; the basic steps involved in milling are –

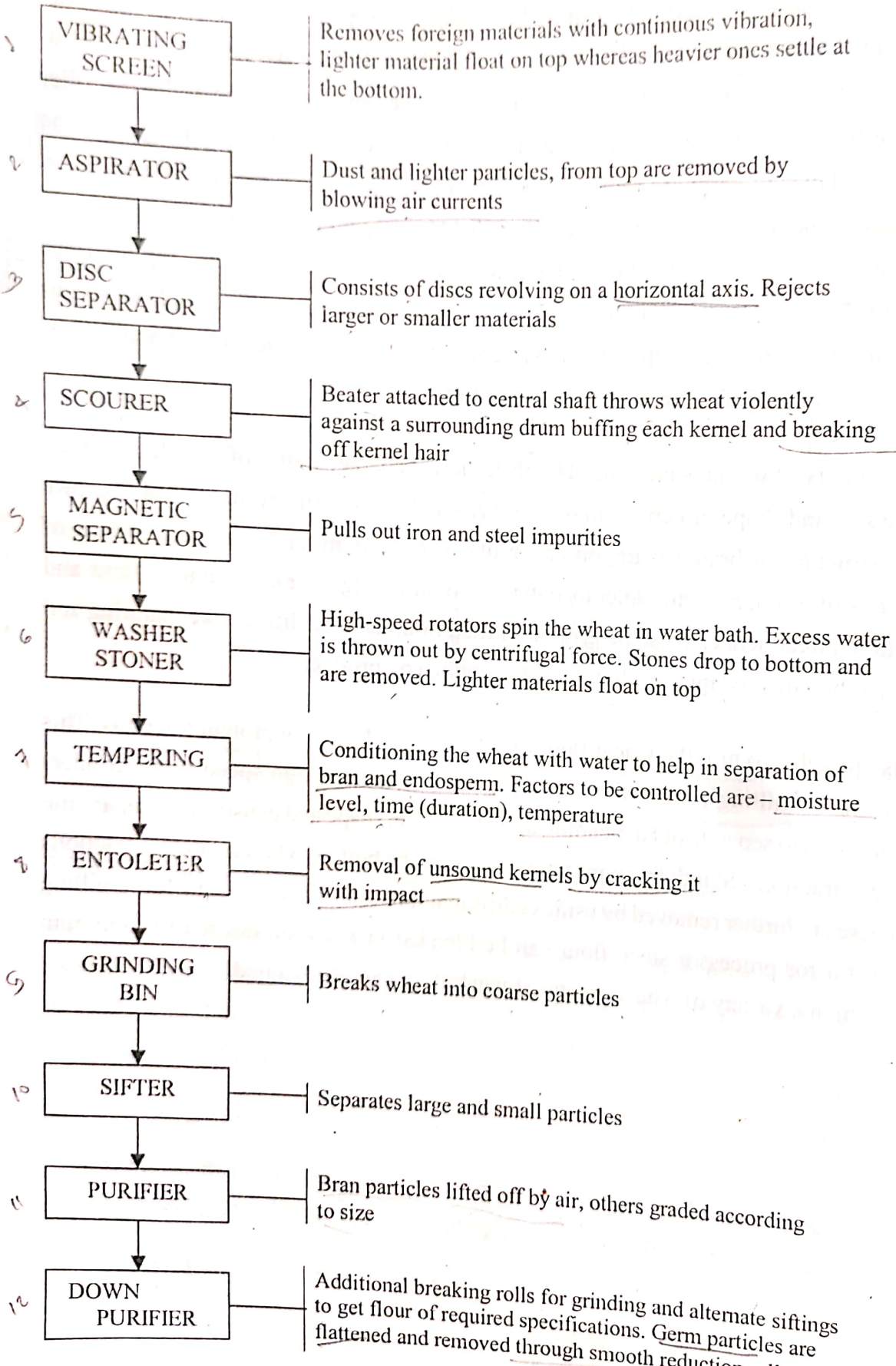
1. Cleaning and washing of wheat
2. Conditioning of the grain to desired moisture content by the addition of water to make the bran and germ pliable, thus preventing them from getting pulverized and
3. Breaking of grain in 4 or 5 stages.

The wheat as received from the grower is first thoroughly cleaned, and then conditioned with water to 14-17% moisture depending upon the variety of wheat to get optimum grinding conditions. Milling involves a progressive series of grinding followed by sieving. First set of rollers break open the bran, and free the germ from the endosperm. The second and third roller further pulverize the rather brittle endosperm and flatten out the more semi-plastic germ. The flakes of bran and flattened germ are removed by the sieves. The pulverized endosperm is run through successive rollers to get fine flours which also gets sifted with each grinding to remove the traces of bran. The range of yield of milled wheat fractions can be as follows – refined flour and semolina - 68-72%, resultant wheat flour - 10%, germ - 1-2% and bran - 18-20%. Many types of semolina flour can be obtained with different varieties of wheat and particle size. Each type of semolina is suitable for preparing certain types of products.

Milling quality of wheat is influenced by the inherent characteristics of the wheat kernel. These could be size and shape of kernel, amount of bran and endosperm, hardness and structure of endosperm, structure of bran, separation capability of endosperm and bran, ash content of different fractions of grain, moisture tolerance during conditioning, extraction rate of flour and grit, etc. Additional treatment can also be given to milled flour using additives like maturing and bleaching agents for a desired quality characteristics in the end product.

It is also possible to mill the wheat flour to get high starch or high protein fractions. This is achieved by '**turbomilling**'. Here, the flour is ground in special high speed turbo grinders which causes particles to separate out depending upon their size, shape and density, thus separating protein and starch fractions. Starch fractions tend to settle at the bottom whereas protein fractions tend to float. These are further removed by using centrifugal force and a stream of air. Turbomilling is extremely useful for processor since flour can be blended in any ratio desired for optimum quality. Thus from one variety of wheat, strong or weak flour can be obtained.

Operational steps in wheat milling :



1.3.4. Wheat products –

Milled wheat products

a. **Refined flour** (maida) – fine endosperm flour used for bakery products like breads, biscuits, cakes, buns, etc., fried snacks and unleavened breads.

b. **Semolina** – coarsely ground endosperm used for manufacture of macaroni products such as vermicelli, noodles and large number of traditional sweet and savory products

c. **Resultant wheat flour** – similar to whole-wheat flour, can be used for chapattis.

d. **Germ** – can be separated and used for industrial purposes (pharmaceuticals and cosmetics)

e. **Bran** – cattle feed, can also be used as a source of dietary fiber.

Processed products

a. **Bulgar wheat** – whole wheat parboiled and broken into shreds, cooked and eaten as breakfast porridge

b. **Malted wheat** – enzyme rich flour used in brewing industry, preparation of malt extract for pharmaceutical purpose, for reducing bulk density of weaning food preparations. Malted wheat flour is prepared by soaking whole-wheat grain for 36 hours in water, germinating in humid conditions for 2-3 days, drying to about 13% moisture content and grinding.

c. **Macaroni products** – these include macaroni, spaghetti, vermicelli and noodles. Semolina from hard variety of wheat is used. It is made into a stiff dough, passed through dies of different shapes and dried. It needs to be cooked in boiling water for a short time before use. Noodles also have egg solids added to the dough. Desired flavorings are added to the product. Precooked ready-to-eat products are also available.

d. **Fortified flour** – A primary fortified product enriched with minerals is available for use in everyday cooking.

e. **Baked products** – varieties of breads, cakes, biscuits etc. are made using maida or whole-wheat flour.

f. **Unleavened breads** – many types of traditional breads like chapati, poori, nan are also made.

g. **Snack items** – deep fat fried snacks are another common product made out of refined wheat flour.

h. **Confectionary** - Wheat flour semolina is also used as a base ingredient for making many traditional sweet meats.

i. **Breakfast cereals** – precooked flaked ready-to-eat cereal items are also made using wheat.

j. **Weaning foods** – precooked wheat cereal for infants are also available.

k. **Dehydrated products** – dehydrated preserved products are also made using refined wheat flour. Traditionally they are sun dried and stored.

1.3.5. Composition and functionality of wheat flour components

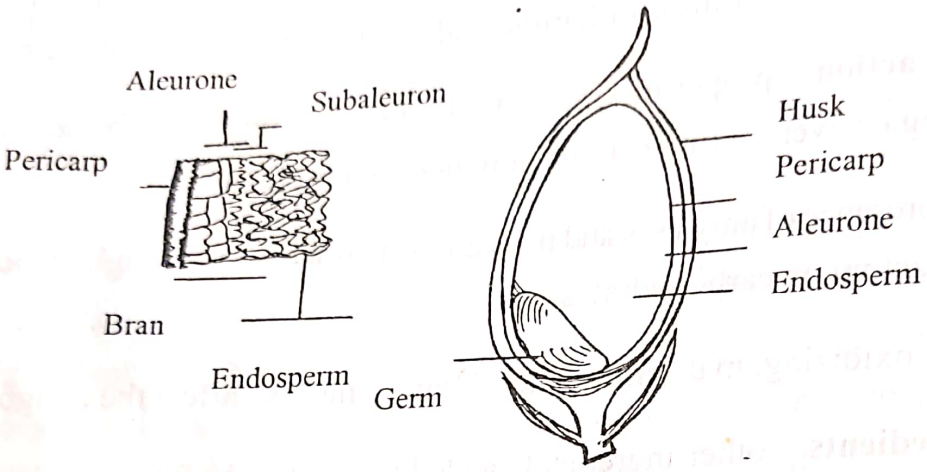
a. **Proteins** – Wheat contains 11% protein which is divided into non-gluten and gluten protein. Non-gluten proteins are albumins (6-12% of total), soluble in water and globulins (5-12% of total) soluble in salt solutions. Wheat is unique in its properties because of presence of gluten proteins. Gluten forms 90% of total wheat proteins and is a mixture of two components – gliadin and glutenin. Gliadin is soluble in alcohol and glutenin in dilute acids. Gliadin is made up of small spherical bodies and glutenin has elongated structure. Both of them when hydrated, associate together to form a network with intra and inter molecular hydrophobic and hydrogen bonds. This results in a cohesive, elastic mass that can hold gases and on application of heat, can expand to a rigid structure giving volume and shape to the product. Crude gluten can be prepared by making a stiff starch by repeated washings with water. By baking this washed gluten, the expansion ability of dough can be demonstrated very well.

b. **Lipids** – Wheat kernel contains about 3% lipids and wheat flour contains about 1.8%. Most of it is bound to gluten and can be extracted with crude gluten. Lipids are important for loaf volume, crumb texture and retard staling in baked products.

c. **Carbohydrates** – The main CHO of flour is starch which forms about 66-68% of flour. In addition, sugars (glucose, maltose and sucrose) are present to the extent of 1.0-1.6%, hemicellulose, 2.3-2.5% and cellulose, 0.3%. On application of heat in wheat products, starch takes up water and is partially gelatinized. Hemicellulose have great water holding capacity, hence they contribute to dough stiffness by preventing movement of water. Sugars help in crust browning and development of flavours.

1.4. RICE

Rice is the largest staple among cereals in the world. It is more common in South East Asian countries. It is grown as paddy and needs to be dehusked before use. This is one cereal where most of it is used as a whole grain. Although many processed rice products are available, the most widely used is in the form of cooked rice grain. The rice kernel is also enveloped in a hull and needs to be dehulled before use. The structure of rice grain is as follows –



Structure of rice grain

1.4.1. Milling of paddy

Milling of paddy is done to dehusk the grain and remove the brown coating of bran to get white colored rice. Paddy yields 22% husk, which is used as fuel for industries, 65% of rice and 5-8% of bran. The extent of bran removed depends upon degree of polishing. In highly polished rice, all the brown layer is removed along with some endosperm.

a. Traditional hand pounding – traditional hand pounding of paddy, done with a wooden staff removes only the husk portion, whereas the brown colored bran layer is retained. Brown rice is highly nutritious but keeping quality is low and broken grains are more thus decreasing yield. The cooking quality of brown rice differs from that of highly polished white rice. It takes more time to cook and the texture is firm and grainy.

b. **Mechanical milling –**

i. Engelburg huller – the Engelburg huller is the simplest of the rice mills. It was the first mechanical milling system introduced during the early part of this century. It is a sturdy machine, simple to operate and can even mill small quantities of paddy. There are about 86,000 units around the country. It consists of a cylindrical rotor fitted in a housing. Bottom half of the housing is fitted with a semi circular sheet. The rotor is driven by a motor and dehusks paddy by abrasive action. High degree of abrasion is used to remove husk and bran in a single operation to reduce the amount of residual paddy. The disadvantages of such a system is that the valuable by-product bran is contaminated with husk, hence cannot be used and yield is low (broken grains are more). However, it is possible to employ two separate operations in this unit to dehusk and polish rice so that pure bran can be obtained.

ii. Double huller – it consists of two hullers, mounted one below the other, on a common stand with gravity flow arrangement for products to move from first to second huller. Husk is removed by aspiration at the product outlet points of both the hullers to reduce contamination from bran. The bran and pulverized husk mixture of the second huller is automatically sieved through a vibrating sifter screen provided below the second huller. Double huller yields relatively pure bran.

iii. Mini rice mill – a full scale mini rice mill has been designed by CFTRI, which can handle 400-500 kg paddy per hour. The mill gives 2% extra rice yield (for raw paddy) and less broken rice over huller mills and bran entirely free from husk. Degree of polish can be adjusted as desired. It consists of a vibratory cleaner for cleaning paddy, a centrifugal sheller for shelling (dehusking), a husk aspirator for aspirating the husk produced during shelling, paddy separator to separate paddy and brown rice obtained from the sheller, and a huller (as polisher) to polish the brown rice. Paddy separated in the paddy separator is fed back to the sheller for shelling, while brown rice goes for polishing. The bran and husk obtained in this mill are both pure.

1.4.2. Rice bran

Rice bran is a highly nutritious by-product of rice industry. It is a rich source of fat (20-22%), protein (12-14%), B-complex vitamins and minerals. Pure rice bran can be used to extract edible grade oil of good quality. However, rice bran is highly unstable because of presence

of enzyme lipase, which breaks down fat into free fatty acids and glycerol within few hours of milling the rice. Hence, bran should be stabilized. The stabilization procedures involve inactivation of lipase, which can be achieved by using heat treatments (steaming, roasting), storing at cold temperatures (cold storage, refrigeration), preservatives and lowering pH (by adding 4% concentrated hydrochloric acid). Stabilized bran can be used for extraction of oil. Bran from parboiled rice is stable for 15 days because it undergoes process of steaming/heating while parboiling.

1.4.3. Parboiling of paddy

The consumption of parboiled rice is very common in Kerala, coastal area of Karnataka, West Bengal and hilly regions of Northern India. Almost 50% of paddy produced in the country is used as parboiled rice. Parboiling is a hydrothermal process, i.e., a technique involving water and heat, where paddy is partially cooked. This is accomplished by soaking, steaming, drying and milling the rice. The parboiling process is to produce physical, chemical and organoleptic modifications in the rice with economic and nutritional advantages. The starch gets partially gelatinized during heating and protein solubility is altered.

The objectives of parboiling are –

a) Increase total yield of paddy

b) Prevent loss of nutrients

c) Salvage wet/damaged paddy

d) Prepare rice according to consumer's requirements.

The advantages of parboiling are –

a) Moisture content in the grain is lowered to 10-11%, hence it stores better.

b) Enzymes are partially or completely inactivate, hence, the formation of free fatty acids on storage is prevented. This is true both for the grain and for the bran.

c) It is a dry, hard grain hence fungus and insect attacks are prevented.

d) On dehusking and polishing parboiled paddy, the bran contains more oil, which can be extracted well, and it is stabilized.

e) Water-soluble vitamins and minerals redistribute in the grain, hence losses are lesser during debranning. Parboiled rice has more vitamins and minerals than raw rice.

Processed rice products –

a. Accelerated aging (aged rice) – since old rice has a better cooking quality, new rice is aged by a process of steaming and drying to give it characteristics of old rice.

b. Breakfast cereals – rice can be converted to flakes, which are used as breakfast cereals.

c. Extruded products – rice can be extruded as noodles or vermicelli, which can be used after rehydration.

d. Weaning foods – precooked, dehydrated rice is processed to weaning foods

e. Fermented foods – rice is used for preparation of fermented beverages, sauces etc.

f. Enriched rice – rice can be enriched or fortified with vitamins by coating it with a mixture of desired nutrients.

g. Quick cooking rice – quick cooking rice or instant rice is available, which only needs reconstitution with hot water.

h. Canned rice – ready-to-eat rice and rice preparations can be canned

i. Preserved products – many dehydrated rice wafers are prepared which are used after deep fat frying. Like papads, they can be stored for a long time.

j. Rice bran – by product of rice milling can be used for edible purposes. At present most of it is used for cattle feed.

k. Rice bran oil – Oil is extracted by solvent extraction from rice bran and sold as edible oil. This oil has cholesterol lowering property due to presence of unsaponifiable fraction Oryzanol, hence is good for health.

1.3. MAIZE OR CORN

sweetness. These have unique functional properties and are used in many processed products.

1.6. OTHER MILLETS

1.6.1. Barley

Barley (*Hordeum vulgare*), is used as pot barley, pearl barley or flour. It is mostly used in the preparation of malt and for therapeutic purposes. For preparation of pot barley, grains are milled by abrasive action to remove hull and aleurone layer, further pearling (polishing) yields pearl barley. These can be ground to give flour.

1.6.2. Oats

Nutritionally oats (*Avenabyzantina*) are the richest cereal. For milling of oats, different steps followed are, a) cleaning, b) drying or light roasting to reduce moisture content to 6% and c) dehulling. Dehulled grains (groats) are steamed and flaked to give oat flakes.

1.6.3. Jowar

Jowar or sorghum (*Sorghum vulgare*) is used as a staple in many states of west and south India. It is converted into flour or parched, pearled or flaked. Malting is also done.

1.6.4. Ragi

Also called finger millet (*Eleusine coracana*), whole ragi flour is used as a staple in south India. It is a rich source of calcium. It is cooked as a dumpling or made into unleavened cakes. Malted and popped products are also very common. Malted ragi is used for preparation of weaning foods. Ragi is also being used for production of extruded products like noodles and vermicelli. Partial replacement of wheat flour in baked products with ragi flour has also been tried and found to be successful. Ragi can also be used for preparing dehydrated preserved products (papads).

1.6.5. Bajra

Bajra (*Pennisetum typhoideum*) is consumed after dehusking in cooked form like rice or converted into flour and made into rotis. This millet can also be parched or malted.